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CLINICAL REVIEW

Protective and risk factors for adolescent sleep: A meta-analytic review

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SUMMARY

Teenagers need sufficient sleep to function well daily, yet consolidated evidence advising which factors protect, or harm, adolescents' sleep is lacking. Forty-one studies, published between 2003 and February, 2014, were meta-analysed. Mean weighted r values were calculated to better understand the strength of protective and risk factors for 85,561 adolescents' (age range = 12-18 y) bedtime, sleep onset latency (SOL) and total sleep time (TST). Results showed good sleep hygiene and physical activity were associated with earlier bedtimes. Video gaming, phone, computer and internet use, and evening light related to delayed bedtimes. Good sleep hygiene negatively correlated with sleep latency. Alternatively, sleep latency lengthened as a negative family environment increased. Tobacco, computer use, evening light, a negative family environment and caffeine were associated with decreased total sleep, whereas good sleep hygiene and parent-set bedtimes related to longer sleep length. Good sleep hygiene appears to be protective, whereas a negative home environment and evening light appear to be risk factors. Cautious use of technology (other than television), caffeine, tobacco and alcohol should be considered. These factors, along with pre-sleep worry, are likely to have some negative impact on sleep. Parent-set bedtimes and physical activity may be beneficial. Future research directions are discussed.

Introduction

The importance of sleep and sleep habits for adolescents

Sleep is an essential part of everyday functioning, therefore restricting it can have multiple, negative consequences [1]. Longitudinal and survey data indicate that adolescents with unrestricted sleep opportunities obtain over 9 h of sleep [2,3]. However, systematic reviews and meta-analyses show millions of adolescents worldwide achieve insufficient sleep (e.g., less than 8 h), especially on school nights [4,5].

Considering only 14% [6] to 27% [1] of adolescents obtain over 9 h of sleep on school nights, and worse still, up to 25% [1] acquire *less than* 6 h, it is hardly surprising that most teenagers wake feeling unrefreshed at least a few times per week [6]. Additionally, the consequences of insufficient sleep extend far beyond morning tiredness [7]. Less than 8 h sleep increases sleepiness throughout the day, and decreases mood, motivation and scores on intelligence tasks [8] and impairs daytime functioning [3]. Conversely, longer sleep duration, better sleep quality and lower daytime sleepiness have been associated with better school performance [9]. Severe restriction of sleep during the week (i.e., less than 6 h/night) is associated with increased interpersonal problems at school, psychological problems, such as lower life satisfaction, lower self-esteem, higher incidence of drug use [1] and a higher rate of motor vehicle accidents [10].

A lack of sleep on school nights is a transcontinental phenomenon, with adolescents' bedtimes delaying during development. Despite later bedtimes, school start times remain constant, resulting in insufficient sleep duration during the school week [11], and catch up sleep when given extended opportunities (i.e., weekends; [5,12]). Given that a lack of sleep is detrimental to healthy functioning and performance [1], it is crucial to identify factors which affect sleep in order to minimise subsequent negative consequences.

Bedtimes and sleep onset latency (i.e., the time it takes to fall asleep; SOL) have been found to negatively correlate with total sleep time (i.e., night time sleep duration; TST) and are also

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Abbreviations

AUDIT	alcohol use disorders identification test
BT	bedtime
CI	confidence interval
EEG	electroencephalography
PSQI	Pittsburgh sleep quality index
SAAQ	sleep anticipatory anxiety questionnaire
SOL	sleep onset latency
SSHS	school sleep habits survey
TST	total sleep time
TV	television
VG	video gaming

associated with fatigue, anxiety and depressed mood [13]. It therefore appears important to investigate not only sleep duration, but also bedtime and sleep latency.

Possible reasons why adolescents do not get enough sleep

"Risk" factors

Many internal and external factors have been identified as detrimental to teens' sleep (e.g., [14]). Although this paper will primarily focus on factors under behavioural control, internal, biological mechanisms also contribute to adolescents' sleep (e.g., [2,14,15]). Physiological sleep pressure takes longer to rise in adolescents than in children, thus it takes longer for adolescents to feel sleepy and prolongs sleep onset [16,17]. Additionally, sleep/wake rhythms naturally drift later in adolescents than in children, meaning their natural inclination is to go to bed later and sleep later [15].

Melatonin, a hormone released by the body in the evening in preparation for sleep, is released later in the evening for older adolescents than younger adolescents, which prolongs the onset of evening sleepiness [14]. Together, these biological mechanisms drive adolescents' tendency to stay up later.

Although not a biological mechanism, teenagers are unable to control their school start time, which remains the same or becomes earlier with increased age. This works against teenagers' inclination to sleep later and results in sleep restriction [14]. Conversely, when adolescents are given the opportunity to start school later in the morning they obtain more sleep and feel less tired throughout the day [11].

Looking to external contributors, much hype surrounds the use of electronic media and its detrimental impact on sleep [18]. However, results from studies concerning the effect of television (e.g., [19]), computer use (e.g., [19,20]), video gaming (e.g., [20]), mobile phone use (e.g., [21]) and internet use (e.g., [22]) have not exclusively nor consistently stated that all these media have a negative impact on adolescent bedtime, sleep latency or duration - nor that the impact is large. Similarly, the effects of substance use, such as caffeine, alcohol and tobacco have shown a variety of effects on sleep, ranging from no relationship of cigarette use [23] and caffeine [24] on weekday sleep, to medium negative effects from alcohol and smoking [25].

Other factors hypothesized to affect adolescent sleep include; time spent with their peers [26]; whether they are worried close to bedtime (e.g., [27]), and; involvement in extracurricular activities, such as sport and work (e.g., [12]). All these factors have been surveyed in relation to sleep habits, and have presented mixed results in terms of the presence and size of the effect. Another external factor proposed to lead to less sleep and later bedtimes is longer day length, which is affected by longitude, latitude and season (e.g., [28,29]). Although day length is not under behavioural control, using room lighting in the evening is. For example, Brazilian adolescents in homes with electric lighting have later bedtimes than those without electric lighting [30].

Despite many factors theorised to negatively impact adolescent sleep, it is difficult to reach conclusions between studies regarding the consequences and severity of these risk factors. Thus, this review aims to consolidate and quantify these research findings using a meta-analytic approach.

Protective factors

A neglected 'half' of the adolescent sleep research field is the investigation of factors benefiting adolescent sleep. Several variables consistently show a protective relationship to adolescents' sleep, bedtime and sleep latency. For instance, adolescents in Australia [31], the United States [12] and Germany [32] all had longer sleep durations when their bedtimes were set by their parents. Better sleep hygiene, such as rarely using one's bed for things other than sleep and relaxing before bed, are positively correlated with sleep duration and negatively correlated with sleep latency [33,34]. A positive family environment, with low conflict [35] or chaos [33], has also been shown to benefit adolescents' sleep patterns.

Although it appears that some factors are harmful, or at least not beneficial, there also seems to be protective factors present. Furthermore, most external factors can be modified through changes in people's behaviour (e.g., restricting caffeine intake, avoiding television before bed, etc.). Understanding these relationships simultaneously will be helpful in shaping teenagers' activities in order to improve their sleep.

Current research and the need for consolidation

Although many studies have looked at the impact of individual risk and protective factors on adolescent sleep, no meta-analysis exists to consolidate or quantify these data. Reliance on individual studies may lead to assumptions and misunderstandings concerning the relationship between sleep and risk or protective factors [36], among both the scientific community and the general population. As the magnitude and consistency of these relationships are currently unknown, synthesis of data could provide assurance that risk factors are actually harmful, and to what extent. Moreover, the importance of actively promoting protective factors, rather than simply decreasing unfavourable behaviour, will be a useful addition to therapy, education programs and developments within the field. A research field often needs collaboration of existing data, rather than more studies, to find consistency, minimise variance, and provide new direction for future research [36]. As such, a meta-analytic approach to consolidate existing data will be used to gain information on protective and risk factors for adolescent sleep.

Method

Literature search

Databases (e.g., Proquest Central, Flinders University search engine, Sage, PubMed, Google Scholar) were searched for articles relating to adolescent sleep. Combinations of keywords, such as 'adolescent,' 'teenage,' 'sleep,' 'parent monitoring,' 'bedtimes,' 'electric light,' 'media use,' 'technology use,' 'sunrise,' 'sunset,' 'longitude,' 'latitude,' 'anxiety,' 'worries,' 'stress,' 'delayed,' 'late,' 'sleep hygiene,' 'substance use,' 'caffeine,' 'adequate sleep' and 'consequences' were used to search for articles which relate to relevant factors on sleep duration, sleep onset latency and bedtime.

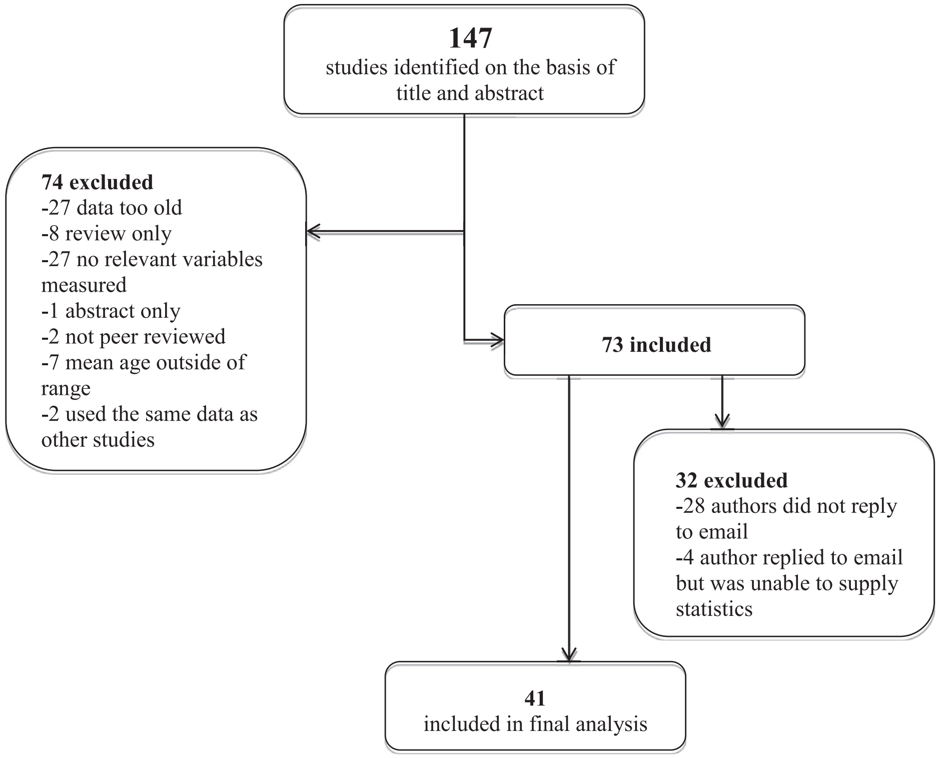

Fig. 1. Flow chart of articles.

Reference lists of studies found through databases were also searched, and articles found when searching literature for related research were considered.

Inclusion criteria

Peer reviewed articles, with a mean sample age between 12 and 18 y were considered for inclusion. Articles needed to measure bedtime, SOL and/or TST, and have collected data within the last 11 y (i.e., 2003 to February, 2014), due to rapid changes in technology during this time period, which may make older findings obsolete. For studies where the year of data collection was not stated, year of publication was used. Language of publication was not an inclusion criteria, however, no non-English publications were found.

Exclusion criteria

Studies were excluded if they were not peer reviewed; if the study focused on an abnormal population (other than delayed sleep phase disorder or insomnia), or; was a review article. Where relevant variables were measured but not reported, authors were emailed requesting the appropriate correlation coefficients. If relevant variables were not measured, or authors did not respond to emails, the study was excluded. Further data offered from emailed authors was accepted if they met all other inclusion criteria.

Coding

Studies were coded by KB, with support from MG. Discrepancies were discussed until consensus was met. A total of 147 studies were identified. Of these, 41 were included in final analyses (see Fig. 1 and Table 1).

Statistical analysis

A weighted mean r value, sampling error variance and variance of population correlation were determined as per Hunter and Schmidt [36].

The weighted average of r was calculated as follows, so that an individual correlation within a study was weighted by the number of persons in the same study:

$$\bar{r} = \frac{\sum [N_i r_i]}{\sum N_i}$$

where $r_i =$ correlation in study i, and; $N_i =$ the numbers of participants in study i.

The sampling error variance was calculated as shown below:

$$\sigma_{e^2} = \frac{\left(1 - \bar{r}^2\right)^2}{\bar{N} - 1}$$

where $\bar{r}^2 =$ the weighted average of r, and; $\bar{N} =$ the average number of people per study.

The estimate of the variance of population correlations was calculated as shown below:

$$\sigma_{\rho^2} = \sigma_{r^2} - \sigma_{e^2} = \sigma_{r^2} - \left(1 - \bar{r}^2\right)^2 \Big/ \left(\bar{N} - 1\right)$$

where $\sigma_{r^2} =$ the observed variance in correlations.

If the relevant correlation coefficient was not provided in the article, authors were emailed requesting data. For studies which presented data as means and standard deviations only, results were converted to the Pearson product–moment correlation coefficient, using a Microsoft Excel conversion calculator [37].

Table 1
Summary of articles included in the meta-analyses.

Author. Year	Sample size (%male)	Country	Age range (mean, standard deviation)	Measure (sleep); weekend/ weekday	Measure (protective/risk factors)
Arora et al., 2013. [60]	632 (36.1)	England	11–18 (13.9, 2.0)	SSHS (SOL, TST); weekday	SSHS (extracurricular); technology use questionnaire (VG, TV, computer, phone)
Billows et al., 2009. [33]	217 (43)	Australia	13–18 (14.9, 1.0)	Self-report questions (SOL, TST); weekday	Confusion hubbub and order scale (family environment); sleep hygiene index (sleep hygiene, caffeine, pre-sleep worry), parental monitoring questionnaire (parent-set BT)
Borisenkov et al., 2010. [52]	1101 (49)	Russian Federation	11–23 (16.1, 3.1)	Munich chronotype questionnaire (BT, SOL, TST); weekday	Longitude & latitude (southern Komi Republic [KR]; Syktyvkar, KR; Inta, KR, & Apatity, Murmansk Region, Russian Federation)
Brand et al., 2009. [40]	246 (24)	Switzerland	(17.58, 1.62)	Sleep log based on PSQI (BT, TST, SOL); weekday	Questionnaire (caffeine, tobacco, alcohol)
Brand et al., 2010. [49]	434 (40)	Switzerland	(17.2, 1.4)	Sleep log based on PSQI (BT, SOL, TST); weekday	Exercise log (physical activity)
Bryant Ludden & Wolfson. 2010. [58]	197 (49)	USA	Grades 9–12	Questionnaire (BT, SOL, TST); weekday	Questionnaire (caffeine)
Chung & Cheung. 2008. [44]	1629 (50)	China	12–19 (14.8, 1.7)	Sleep-wake habit questionnaire, modified from PSQI (BT, TST), sleep quality index (SOL); weekday	Questionnaire (work, physical activity, tobacco, alcohol, caffeine)
Collado Mateo et al., 2012. [47]	2649 (51)	Spain	12–16 (14.09, 1.33)	SSHS (BT, SOL, TST); weekday	SSHS (parent-set bedtime)
Condén et al., 2013. [27]	5012 (50)	Sweden	15–18	Questionnaire (TST); weekday	Questionnaire (tobacco, computer, physical activity); AUDIT (alcohol)
Drescher et al., 2011. [57]	319 (52)	USA	10–17 (13.3, 1.8)	Sleep habits questionnaire (BT, TST, SOL); weekday	Questionnaire (VG, caffeine, work)
Dworak et al., 2007. [62]	11 (100)	Germany	12–14 (13.45, 1.04)	PSG (SOL, TST)	Experiment (VG, TV, control)
Engelhardt et al., 2013. [67]	41 typically developing (100)	USA	8–17 (12.2, 2.4)	Parent report (TST); combined	Parent report (TV, VG)
Figueiro & Rea. 2010. [28]	16 (63)	USA	13–14	Sleep log (sleep onset[a], TST); Wednesday	Sleep log [b](evening light)
Fuligni & Hardway. 2006. [65]	761	USA	14–15	Questionnaire (TST); weekday	Questionnaire (homework, peers, TV, computer)
Gaina et al., 2005. [19]	643 (48)	Japan	12–15	Questionnaire (BT, TST; weekday, SOL; combined)	Questionnaire (physical activity, homework, TV, VG)
Garmy et al., 2012. [53]	Grade 8 = 782, grade 10 = 1026	Sweden	Grade 8 (14), grade 10 (16)	questionnaire regarding sleep and lifestyle (BT, TST); weekday	Questionnaire (TV, computer)
Gradisar et al., 2011. [43]	49 (53)	Australia	11–18 (14.6, 1.0)	Sleep diary (BT, SOL, TST); weekday	Questionnaire (caffeine use, alcohol, tobacco)
Gradisar et al., 2013. [7]	171	USA	13–18	Questionnaire (BT, SOL, TST); weekday	Questionnaire (caffeine, TV, computer, phone, VG)
Heath et al., 2014. [59]	16 (44)	Australia	14–19 (17.4, 1.9)	Subjective SOL – direct question	Lux meter (evening light)
Hiller et al., 2014. [61]	40 (53)	Australia	11–19 (15.2, 1.5)	Seven day sleep diary (SOL); weekdays	Sleep anticipatory anxiety questionnaire (SAAQ; pre-sleep worries), questionnaire (caffeine)
Honda et al., 2008. [50]	2160 (100)	Japan	Grades 10–12	Questionnaire (BT), calculated (TST [from BT & risetime]); weekday	Questionnaire (TV, internet, evening light, homework, phone, physical activity)
Huang et al., 2013. [45]	33390 (45)	China	11–18	Questionnaire (BT); weekday	Questionnaire (physical activity, alcohol, smoking)
Kalak et al., 2012. [64]	80 (55)	Switzerland	12–20 (16.28, 2.0)	EEG (SOL, TST); not specified	Family climate questionnaire (family environment)
King et al., 2013. [63]	17 (100)	Australia	15–17 (16, 1)	PSG (SOL, TST)	Experiment (VG)
King et al., 2014. [55]	1287 (50)	Australia	12–18 (14.9, 1.5)	Sleep activity and media questionnaire (BT, SOL, TST calculated); weekday	Questionnaire (internet, VG, TV)
Loessl et al., 2008. [42]	601 (50)	Germany	12–18 (15.4, 1.7)	SSHS (BT, SOL, TST); weekday	SSHS (parent-set bedtime, physical activity, work, extracurricular, alcohol, tobacco)
Megdal & Schernhammer. 2007. [46]	131 (45)	USA	13–18 (15.6)	PSQI (BT, SOL, TST); combined	Questionnaire (tobacco, physical activity)
Ortega et al., 2010. [51]	2179 (48)	Spain	13–18.5	Questionnaire (BT), calculated (TST [from BT & rise time]); weekday	Questionnaire (physical activity, TV)
Oshima et al., 2012. [66]	17920 (31)	Japan	Grades 7–12	Self-report (TST); combined	Questionnaire (mobile phone, alcohol)
Pasch et al., 2012. [23]	704 (49)	USA	10–17 (14.7, 1.83; at wave 1)	Questionnaire (BT) calculated (TST [from BT & wake time]); weekday	Questionnaire (alcohol, tobacco)
Peixoto et al., 2009. [30]	37 (38)	Brazil	11–16 (13.1, 1.7)	Actigraphy (sleep onset[a], TST); weekday	Electric/non electric home lighting; lux (evening light)
Pieters et al., 2012. [54]	1926 (45)	Belgium	13–20 (16.9, 1.5)	SSHS (BT, SOL); weekday	Questionnaire (TV, computer, phone, VG)
Randler. 2008. [29]	674 (49)	Germany	11–16 (13.3,1.66)	Questionnaire (BT), calculated (TST [from BT & risetime]); weekday	Locality (East Germany [Leipzig], West Germany [Stuttgart, Ludwigsburg])

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Table 1 (*continued*)

Author. Year	Sample size (%male)	Country	Age range (mean, standard deviation)	Measure (sleep); weekend/weekday	Measure (protective/risk factors)
Randler et al., 2009. [32]	784 (45)	Germany	11–20 (15.18, 2.14)	Questionnaire (BT), calculated (TST [from BT & risetime]); weekday	Adapted SHSS (parent-set BT)
Saxvig et al., 2012. [25]	1285 (52)	Norway	16–19 (17.3, .9)	Questionnaire (BT, SOL, TST); weekday	Questionnaire (tobacco), AUDIT (alcohol)
Shochat et al., 2010 [56]./ Tzischinsky & Shochat. 2011. [48][c]	449 (50)	Israel	(14, .8)	SSHS (TST, SOL, bedtime); weekday	Electronic media and fatigue questionnaire (TV, VG, internet), SSHS (parent-set BT)
Short et al., 2011. [31]	385 (59)	Australia	13–18 (15.6, .95)	Sleep diary (BT, SOL, TST); weekday	SHSS (parent-set BT, physical activity, extracurricular, homework, work, caffeine, alcohol, tobacco), SAAQ (pre-sleep worry)
Storfer-Isser et al., 2013. [34]	514 (49)	USA	16–19 (17.7, .4)	Sleep log (BT, SOL, TST); weekday	ASHS (sleep hygiene, pre-sleep worry, caffeine, alcohol, tobacco)
Tan et al., 2012. [38]	33 (45)	New Zealand	10–18 (12.9,2.19)	Questionnaire (BT, SOL, TST); weekday	ASHS (sleep hygiene, caffeine, alcohol, tobacco, pre-sleep worry)
Teixeira et al., 2004. [41]	27 (48)	Brazil	14–18 (16.6,1.1)	Actigraphy and activity diary (BT, SOL, TST); weekday	Questionnaire (work, extracurricular, physical activity, tobacco, alcohol)
Yen et al., 2008. [35]	8004	Taiwan	12–18 (14.7,1.7)	Questionnaire (TST); combined	Questionnaire (internet, caffeine, peers, work, family environment)

Note: ASHS = Adolescent sleep hygiene scale; AUDIT = alcohol use disorders identification test; BT = bedtime; EEG = Electroencephalography; PSQI = Pittsburgh sleep quality index; SAAQ = sleep anticipatory anxiety questionnaire, questions 11–15; SOL = sleep onset latency; SSHS = school sleep habits survey; TST = total sleep time; TV = television; VG = video gaming.
[a] Measured sleep onset, not bedtime.
[b] Personal circadian light measurement device.
[c] Same participants, data published in separate articles.

Both Pearson's *r* and Spearman's rho were considered appropriate correlation coefficients for meta-analysis, as they have the same sampling error variance. Despite point–biserial correlations having larger standard errors than Pearson's *r*, deletion of studies providing point–biserial correlation coefficients was not feasible, due to the low number of studies in the meta-analysis that would result if they were excluded [36]. Furthermore, weighted averages were not transformed to Fisher's *z*, as this transformation weights larger correlations more than smaller correlations, leading to an upward bias [36].

Results from individual studies included in the meta-analysis did not control for other variables (e.g., age, sex), in order to best synthesize results. Where possible weekday data were used, however, combined weekday and weekend data were analysed when necessary. Only the first point of data were included from longitudinal studies [23] and pre-post intervention studies [38].

Cohen's criteria were used as cut-offs for the magnitude of effect sizes [39], where *r* values of .10–.30 were considered small; .30 – .50 medium, and; above .50 considered large [39]. Thus, weighted *r* values greater than .10 (or less than −.10) were considered to be associated with sleep variables, more so than protective and risk factors which fell between −.10 and .10 [39].

Confidence intervals (CIs) for the variance of population correlations were also calculated for each weighted *r* value, reflecting precision after removal of sampling error. As such, CIs suggest unexplained variance, with intervals that span zero indicating no evidence for the relationship between the sleep variable and the protective/risk factor, and large intervals suggesting the potential for moderating or mediating factors.

Results

The sample consisted of 85,561 adolescents in the age range of 10–23 y, with reported mean ages ranging from 12.2 to 17.7 y. All protective and risk factors associated with sleep variables displayed a small to medium correlation (i.e., ± .10 to ± .30).

Risk and protective factors associated with bedtime

Internet use, exposure to evening light before bed, computer use, mobile phone use, video gaming and negative family environment (based on one study) were positively correlated to bedtimes. Sleep hygiene and physical activity were factors negatively associated with bedtimes. That is, as these factors increased, bedtime became earlier. All other variables had a minimal effect on bedtime. See Table 2 for weighted *r*s and variance statistics. Variables are ranked from the largest negative correlation, to the largest positive correlation, indicating the most protective to the least beneficial, respectively. Refer to Fig. 2 for CIs.

Risk and protective factors associated with sleep onset latency

Table 3 presents the weighted *r*s and variance statistics for sleep latency, ordered from the most beneficial to the highest risk. Sleep onset latency was positively correlated with a negative family environment. That is, as this factor increased, SOL lengthened. Alternatively,

Table 2
Mean weighted *r* between bedtime and protective/risk factors.

Variable	Mean weighted *r*	σ_{e^2}	σ_{ρ^2}	*K*
Tobacco [23,25,31,34,38,40–46]	−.183	.000	.013	12
Sleep hygiene [33,34,38]	**−.172**	**.004**	**−.004**	**3**
Alcohol [23,25,31,34,38,40–45]	−.156	.000	.007	11
Parent-set bedtime [31–33,42,47,48]	−.143	.001	.040	6
Physical activity [19,31,42,44–46,49–51]	**−.137**	**.000**	**.003**	**9**
Longitude [29,52]	−.097	.000	−.000	2
Extracurricular activity [31,41,42]	−.049	.003	−.001	3
Homework [19,31,50]	.038	.001	−.000	3
Television [7,19,50,51,53–56]	.041	.001	.005	8
Work [31,41,42,44,57]	.066	.002	.006	5
Caffeine [7,31,33,34,38,40,43,44,57,58]	.074	.003	.002	10
Pre-sleep worry [31,33,34,38]	.091	.004	−.001	4
Latitude [52]	.099	.000	−.000	1
Negative family environment [33]	*.103*	*.005*	*−.005*	*1*
Video gaming [7,19,54–57]	*.120*	*.001*	*.001*	*6*
Phone use [7,50,54]	*.131*	*−.000*	*.000*	*3*
Computer use [53,54]	*.148*	*.000*	*.003*	*2*
Evening light [28,30,50]	*.169*	*.001*	*−.000*	*3*
Internet [7,50,55,56]	*.212*	*.001*	*.003*	*4*
Time spent with peers	–		–	0

Note: σ_{e^2} = sampling error variance; σ_{ρ^2} = variance of population correlations; *K* = number of studies; bold = protective factors (i.e., factors where $r < -.1$ and CI does not overlap 0); italicized = risk factors (i.e., factors where $r > .1$ and CI does not overlap 0).

a positive association was seen between SOL and sleep hygiene, with SOL decreasing as sleep hygiene improved. Other variables had weak correlations with SOL. It should be noted that computer use, evening light, longitude and latitude only had one study each, therefore could not be appropriately used in meta-analysis. Refer to Fig. 3 for CIs.

Risk and protective factors associated with total sleep time

Overall, tobacco use, computer use, evening light, a negative family environment and caffeine consumption had the largest negative associations with TST. Parent-set bedtime had the greatest positive correlation, followed by good sleep hygiene practises. No support was found for the association between all other variables and TST. See Table 4 for weighted *r*s and variance statistics. Confidence intervals are displayed in Fig. 4.

Caffeine consumption

Due to differences in measurement between the 11 studies analysed, the consumption of caffeine is presented according to different definitions of the "caffeine" variable, to determine if a particular beverage, or time of consumption, had a stronger relationship with sleep.

No evidence was found for a relationship between caffeine and bedtime (see Table S1), or caffeine and SOL (Table S2), regardless of the operationalization of caffeine consumption, with the exception of a small, positive effect found between coffee/tea use and bedtime (see Table S1). However, slight variations in relationship strength

Table 3
Mean weighted *r* between sleep onset latency and protective/risk factors.

Variable	Mean weighted *r*	σ_{e^2}	σ_{ρ^2}	*K*
Sleep hygiene [33,34,38]	**−.172**	**.004**	**.003**	**3**
Physical activity [19,31,42,44,46,49]	−.081	.002	.001	6
Evening light [59]	−.029	.067	−.067	1
Alcohol [25,31,34,38,40–44]	−.029	.002	.008	9
Extracurricular activity [31,41,42,60]	−.025	.004	−.002	4
Homework [19,31]	−.016	.002	.007	2
Tobacco [25,31,34,38,40–44,46]	−.015	.002	.011	10
Caffeine [7,31,33,34,38,40,43,44,57,58,61]	−.015	.003	.003	11
Parent-set bedtime [31–33,42,47,48]	−.014	.003	.007	6
Work [31,35,41,44,57]	.010	.002	.000	5
Television [7,19,54–56,62]	.010	.001	.000	6
Video gaming [7,19,54–57,62,63]	.031	.001	−.000	8
Phone use [7,54]	.039	.001	−.001	2
Computer use [54]	.040	.000	−.000	1
Latitude [52]	.072	.000	−.000	1
Internet [7,55,56]	.080	.002	.003	3
Longitude [52]	.086	.000	−.000	1
Pre-sleep worry [31,33,34,38]	.137	.002	.010	5
Negative family environment [33,64]	*.243*	*.006*	*−.001*	*2*
Time spent with peers	–		–	0

Note: σ_{e^2} = sampling error variance; σ_{ρ^2} = variance of population correlations; *K* = number of studies; bold = protective factors (i.e., factors where $r < -.1$ and CI does not overlap 0); italicized = risk factors (i.e., factors where $r > .1$ and CI does not overlap 0).

arose when analysed for TST (refer to Table 5 for weighted *r*s and variance statistics and Fig. 5 for CIs). When all types of consumption were included in the meta-analysis (multiple measures per study were averaged where applicable), a small, negative correlation was

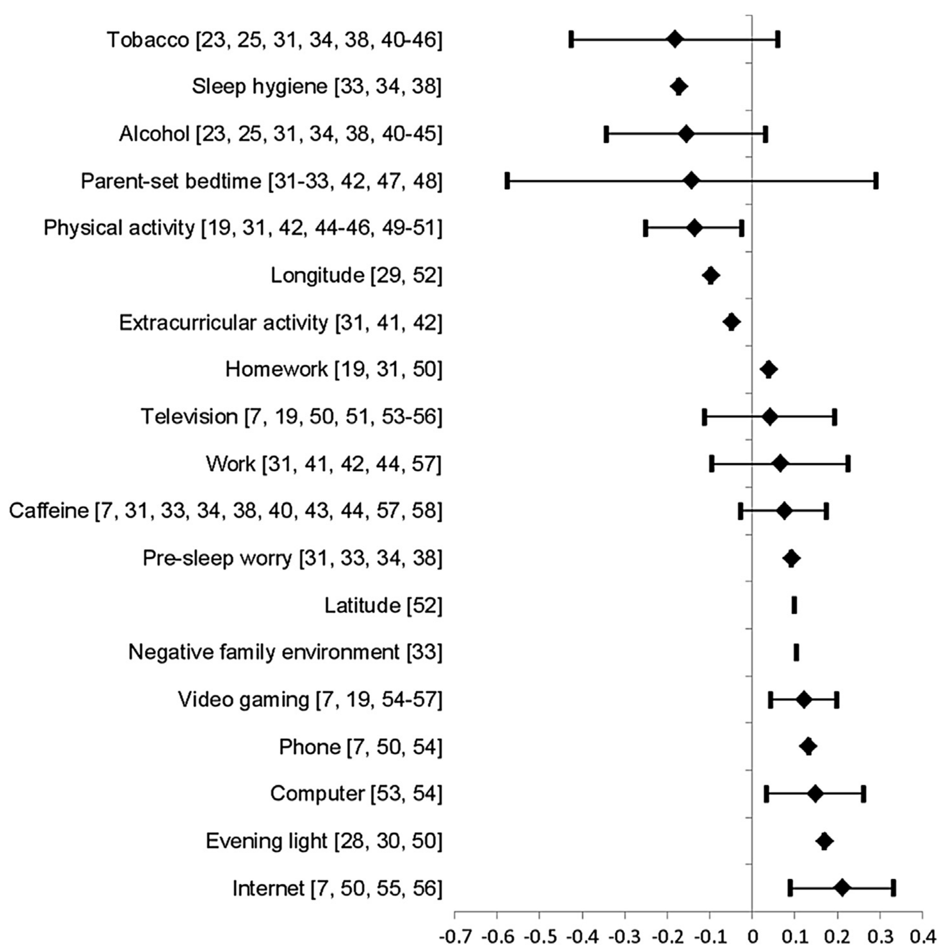

Fig. 2. Forest plot presenting the mean weighed correlation coefficients and confidence intervals for protective/risk factors and bedtime. Note: dash without a marker represents the data point for variables where $N = 1$.

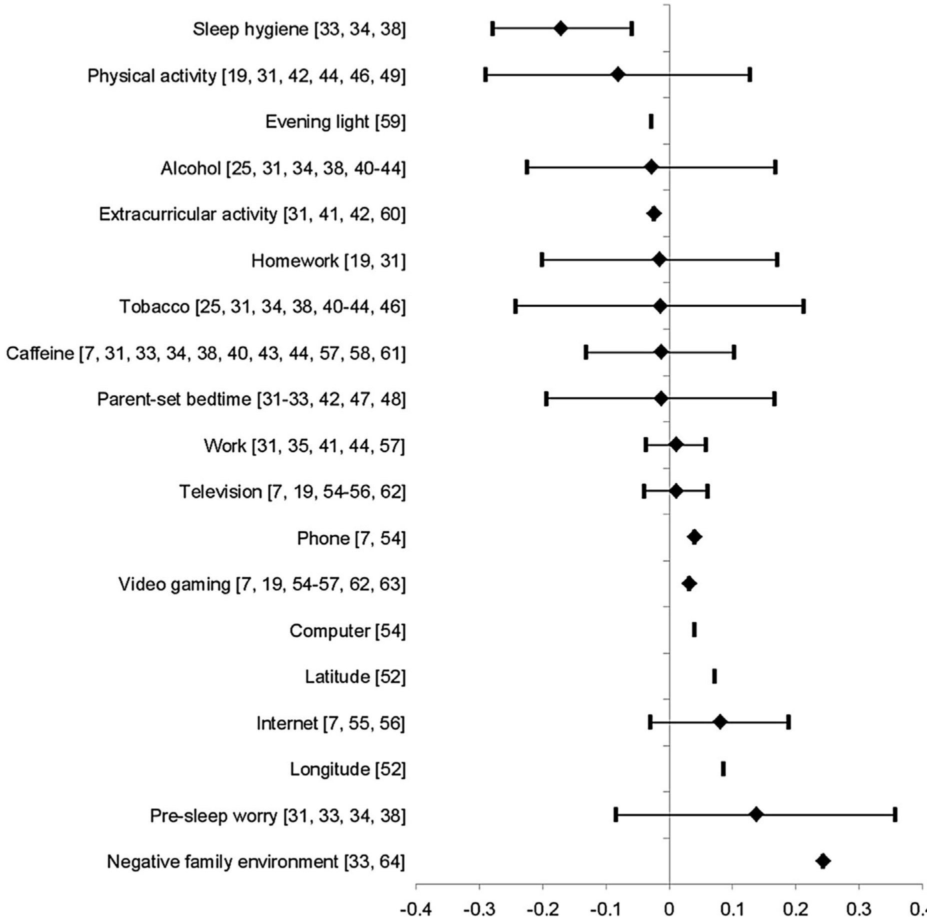

Fig. 3. Forest plot presenting the mean weighed correlation coefficients and confidence intervals for protective/risk factors and sleep onset latency. Note: dash without a marker represents the data point for variables where $N = 1$.

found between caffeine use and TST (see Table 4). Evening caffeine consumption also had a small, negative effect size. There was no support, however, for the association between drinking caffeinated soda and TST, nor was caffeine consumption defined as "coffee" or "coffee/tea" intake related to TST. Caffeinated energy drink consumption was only assessed individually in one study [58]. Bryant Ludden and Wolfson [58] found no relationship for TST (Table 5) or bedtime, however, a small, positive correlation was found between energy drinks and SOL (see Table S2).

Table 4
Mean weighted r between total sleep time and protective/risk factors.

Variable	Mean weighted r	σ_{e^2}	σ_{ρ^2}	K
Tobacco [23,25,27,31,34,38,40–44,46]	*−.183*	*.001*	*.006*	*12*
Computer use [27,53,60,65]	*−.157*	*.001*	*.000*	*4*
Evening light [28,30,50]	*−.138*	*.001*	*−.000*	*3*
Negative family environment [33,35,64]	*−.133*	*.000*	*.001*	*3*
Alcohol [23,25,27,31,34,38,40–44,66]#	−.123	.001	.007	15
Caffeine [7,31,33–35,38,40,43,44,57,58]	*−.116*	*.001*	*.002*	*11*
Phone use [7,50,60,66]#	−.104	.000	.006	7
Internet use [7,35,50,55,56]	−.087	.000	.003	5
Homework [19,31,50,65]	−.076	.001	.005	4
Work [31,35,41,42,44,57]	−.062	.001	.000	6
Video gaming [7,19,55–57,60,63,67]	−.059	.002	−.000	8
Television [7,19,50,51,53,55,56,60,65,67]	−.059	.001	.002	10
Extracurricular activity [31,41,42,60]	−.054	.004	−.002	4
Pre-sleep worry [31,33,34,38]	−.030	.004	.013	4
Latitude [52]	−.019	.000	−.000	1
Time spent with peers [35,65]	.014	.000	.002	2
Longitude [29,52]	.070	.000	.001	2
Physical activity [19,27,31,42,44,46,49–51]	.118	.001	.007	9
Sleep hygiene [33,34,38]	**.200**	**.004**	**.002**	**3**
Parent–set bedtime [31–33,42,47,48]	**.218**	**.001**	**.002**	**6**

Note: σ_{e^2} = sampling error variance; σ_{ρ^2} = variance of population correlations; K = number of studies; bold = protective factors (i.e., factors where $r > .1$ and CI does not overlap 0); italicized = risk factors (i.e., factors where $r < -.1$ and CI does not overlap 0); # = Oshima et al. [66] provided data for four separate samples within the same study.

Discussion

Summary of findings

Overall, good sleep hygiene and physical activity were associated with earlier bedtimes. On the other hand, internet use, evening light, computer use, phone use, and video gaming were related to later bedtimes. Good sleep hygiene was also correlated with shortened sleep latency. Alternatively, sleep latency lengthened as negative family environment increased. Tobacco use, computer use, evening light, a negative family environment and caffeine use were associated with decreased sleep duration, whereas good sleep hygiene and parent-set bedtimes were related to longer sleep length. Thus of all factors analysed, sleep hygiene was related to all three sleep parameters. Nevertheless, this meta-analysis also observed other factors that possess the potential to affect sleep.

Risk factors

Family environment

In terms of factors which may be harmful to adolescent sleep, a negative family environment was associated with longer sleep

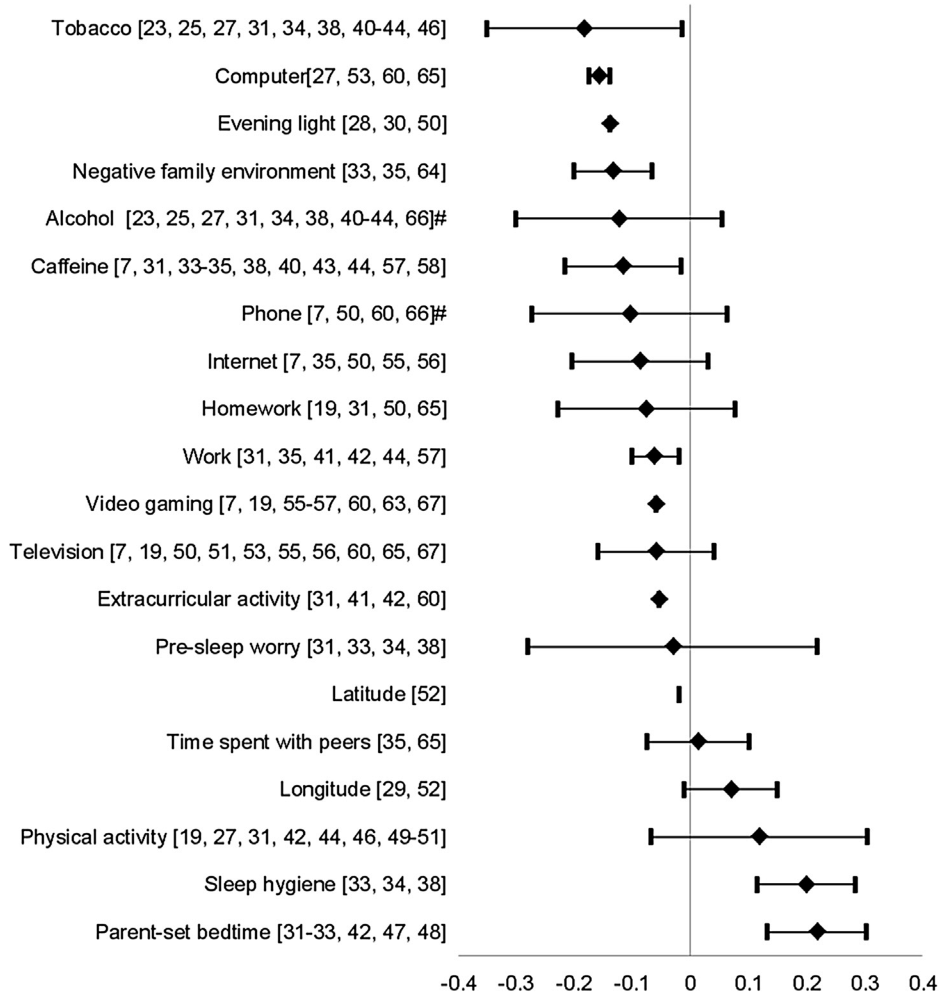

Fig. 4. Forest plot presenting the mean weighed correlation coefficients and confidence intervals for protective/risk factors and total sleep time. Note: dash without a marker represents the data point for variables where $N = 1$; # = Oshima et al. [66] provided data for four separate samples within the same study.

latencies and short sleep duration. The one study that assessed bedtime also found that a negative home environment was associated with later bedtimes [33]. Findings in the present meta-analysis support previous findings that a negative or disorganised home environment is detrimental to adolescents' sleep [33,35,64]. According to Tynjälä and colleagues [68] a positive home atmosphere, in contrast to a negative home environment, may create a foundation for healthy behaviours, including sufficient sleep [68].

Evening light

Evening light was related to delayed bedtimes and shorter sleep duration. This may be due to the opportunities that evening light creates [28,30]. For example, longer day length may facilitate more

Table 5
Mean weighted r for caffeine use variables and total sleep time.

Variable	Mean weighted r	σ_{e^2}	σ_{ρ^2}	K
Coffee/tea only [31,40,44,58]	−.147	.002	.006	5
Evening use [7,33–35,38]	*−.106*	*.001*	*.000*	*5*
Energy drink [58]	−.09	.005	−.005	1
Caffeinated soda [31,43,58]	−.004	.005	−.002	3

Note: σ_{e^2} = sampling error variance; σ_{ρ^2} = variance of population correlations; K = number of studies; italicized = risk factors (i.e., factors where $r < -.1$ and CI does not overlap 0).

participation in outdoor, evening activities [28], hence delaying bedtime and leading to less time sleeping. This hypothesis may also explain why providing electric lighting in adolescents' homes leads to poorer sleep outcomes [30], as the adolescent may be invested in continuing activities made available with indoor lighting.

Alternatively, bright light may alter circadian rhythm timing [69]. Evening light can delay the circadian phase (i.e., the core temperature minimum), making it difficult to fall asleep at a typical bedtime [69]. It can also have an alerting effect, suppressing melatonin levels which would otherwise typically increase as the body prepares for sleep [70]. As light suppresses melatonin and increases alertness, outdoor, indoor and/or screen light may be capable of decreasing subjective sleepiness, delaying bedtimes, and leading to shorter sleep length.

We should caution here that although bright light before bed was not associated with prolonged sleep latency, these results were only based on one study [59], which assessed 1 h of pre-bed bright screen light on sleep. Among adult samples, longer durations of bright, evening screen light has decreased subjective sleepiness [70], and impacted sleep latency [71]. Due to continued mixed results concerning the effect of screen light exposure on sleep, further investigation is necessary to establish the duration of bright light, the threshold of luminance needed for an effect, and the timing of exposure, before conclusions can be made about the extent to which bright light affects adolescents' sleep latency [59].

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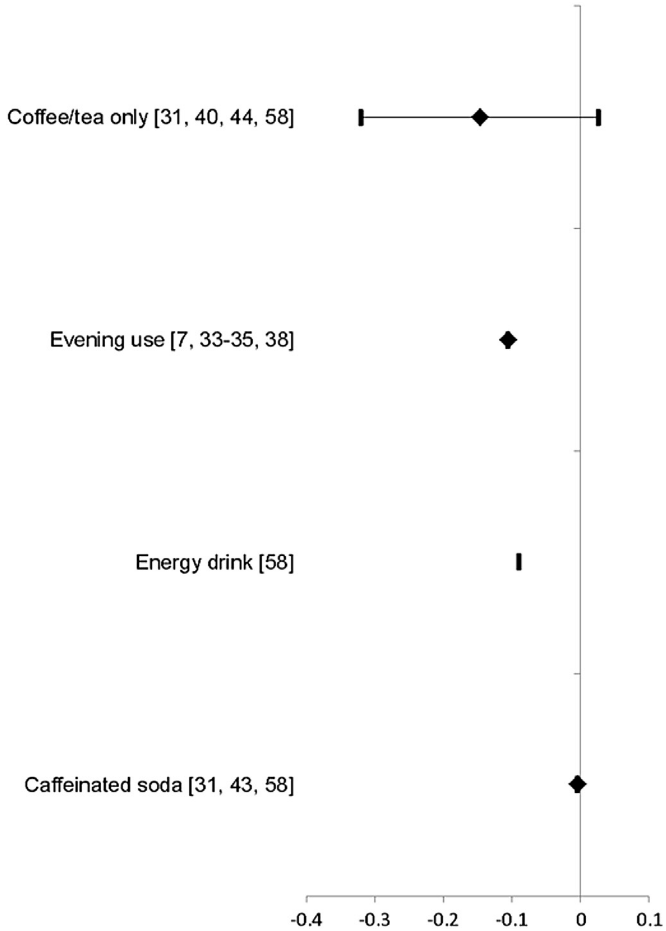

Fig. 5. Forest plot presenting the mean weighed correlation coefficients and confidence intervals for various types of caffeine use and total sleep time. Note: dash without a marker represents the data point for variables where $N = 1$.

Technology use

Despite many online media claims branding technology as a culprit for causing devastating effects on teenage sleep (e.g., [18,72]), the correlations between technology use and sleep were small. One of the five technological devices measured (computers) was related to less total sleep. Internet, computer and phone use, and video gaming, were all associated with later bedtimes, albeit showing small effects. These technologies may engage the user so that they become distracted or apathetic towards the time, thus displacing bedtime [13,73]. The physical, emotional or psychological arousal which may take place when using these devices could lead adolescents to feel less sleepy, once again causing later bedtimes [13,73]. Sleep may then be restricted when needing to wake up for school the following morning.

Many teenagers use their phone *after* sleep onset [74], disrupting sleep and leading to less total sleep time. With the internet now accessible on portable devices, such as cell phones [75], future studies may need to consider whether internet use (such as connections to social media) is disrupting adolescent sleep in a similar way to text messaging.

As the present meta-analysis was correlational in nature, it is possible that adolescents entertained themselves through the use of technology whilst waiting for sleep [76]. While this explanation is plausible, Pieters and colleagues [54] found adolescents whose parents set rules regarding the duration and timing of television viewing, computer use and video gaming had earlier weekday bedtimes than those without parental restriction [54]. Though it may be that adolescents who feel less tired in the evening fill the void with technology use rather than sleep [76], the observation that adolescents with technology restrictions have earlier bedtimes [54] suggests the contrary: that technology use leads to later bedtimes. These meta-analytic results demonstrate the contribution technology use has in delaying adolescents' bedtimes. Although not all devices were associated with less total sleep time, caution needs to be taken by adolescents using technology, to minimize its impact on sleep.

Substance use

Caffeine

Caffeine use was only found to be associated with shorter sleep duration. This may indicate two things. First; the use of caffeine makes adolescents more alert and unable to sleep [24], or, alternatively; adolescents who obtain less sleep are more tired, thus drink caffeinated beverages in an attempt to fight fatigue [58]. Some adolescents may use caffeine to increase alertness yet for others, alertness may be a by-product of ulterior motives, such as "*to experiment*" and "*to have fun*" [58], with one consequence being less sleep duration. Bryant Ludden and Wolfson [58] found that consumers of multiple types of caffeinated beverages (such as those in the current meta-analysis) were more likely to use caffeine for the purpose of "*getting through the day*", and had earlier school day rise times, than low caffeine users or adolescents who consumed high amounts of soda [58], supporting the idea that adolescents who sleep less are more likely to use caffeine. Importantly, according to the current meta-analysis, caffeine use, including combined beverage use and use in the evening, has a small impact on sleep duration. Thus, it is important for adolescents using caffeine for reasons such as "*to appear interesting*" or "*have fun*" to comprehend that less sleep may result from their behaviour. For adolescents who primarily consume caffeine as a means of increasing alertness, intervention would need to educate that increased caffeine consumption may later inhibit ability to obtain adequate sleep, as well as tackling other causes for why insufficient sleep is obtained.

Tobacco

Tobacco was related to less total sleep time. Cigarette smokers are more likely to have trouble staying asleep than those who do not smoke [77]. These disruptions in sleep, would, in turn, lead to less sleep quantity. Future research may wish to look at the sleep of adolescent smokers verse non-smokers. For example, a pre-post design could be employed, whereby current adolescent smokers' sleep is measured before and after a period of abstinence (after withdrawal effects have diminished), in order ascertain whether sleep improves.

Factors which are neither risky nor protective

Technology use

In terms of technology use, television was not related to bedtime, and none of the technology variables (i.e., video gaming, phone, computer and internet use and television) were related to sleep latency. Furthermore, phone use, internet use, video gaming and television were not related to sleep duration. What can be made of these mixed results? Calamaro and colleagues [24] found that night time media use of a variety of individual devices did not impact sleep duration. However, technological multi-tasking, that is, using more than one technological device at a time, was associated with less sleep [24].

Possible mechanisms for technology affecting sleep, such as displaced bedtime, increase in arousal and exposure to bright light which may delay the circadian rhythm [13,73] all have increased opportunity to affect sleep when adolescents are interacting with multiple devices. Unfortunately, multi-tasking could not be measured in this meta-analysis due to a lack of literature and required statistics [24].

Device content should also be considered. Interactive forms of technology, such as computers, cell phones, and video gaming have been found to affect sleep above those which were passive, such as television [7]. The current meta-analysis supported these findings to some extent, as watching television was not related to sleep variables. However, devices which were interactive (video gaming), or had the potential to be interactive (e.g., computer use and internet use) were not always related to poor sleep. This may be in part that the *content* of computer and internet use were not ascertained in the present meta-analysis, therefore, hypothetically, adolescents could have been using these media for passive activities, such as watching movies, with subsequently less impact on their sleep.

As with bright light, the timing and duration of technology use may need to be more specifically studied, using experimental designs, before the true effects can be disentangled. For example, one experiment of males, aged 15 to 17 y, demonstrated that 50 min of pre-bed video gaming did not impact objective sleep duration or subjective SOL, whereas 150 min decreased sleep duration and increased SOL [63]. This implies that the association between technology use and sleep is not straight forward. The number of devices used [24], the content of the device [7] and the duration of use [63] may all contribute to how technology influences adolescents' sleep.

Substance use

Caffeine

Despite caffeine use being associated with lower total sleep time, it was generally not associated with sleep latency or bedtime, although coffee/tea consumption was marginally related to later bedtimes. Calamaro and colleagues [24] found that caffeine consumption was 76% higher among teenagers who fell asleep at school than those who did not, demonstrating that caffeine may be used to combat fatigue, however, it may not fully overcome sleep pressure [24]. It is plausible that adolescents who sleep less are more likely to consume caffeine, yet also have higher sleep pressure, which counteracts caffeine's alerting effects. This could explain the findings of the present meta-analysis, as despite caffeine and sleep duration being negatively correlated, if adolescents who are more tired (and have less sleep) are higher consumers of caffeine, their sleep pressure and caffeine use may cancel each other out, resulting in similar bedtimes and sleep latencies for both high and low consumers of caffeine. Nevertheless, experiments, as opposed to correlational studies, are needed to determine the effects of caffeine, and the timing of its consumption, on adolescent sleep.

Alcohol and tobacco

Alcohol was not related to any sleep variables and tobacco use showed no relationship between bedtime or sleep onset latency. Links have been found between longer sleep latency and adult smokers [78], yet there is a lack of published literature concerning the same link in adolescents. Most of the data collected for the current meta-analysis were due to the generous contribution of authors replying to emails sent by KB requesting results. As such, it is difficult to ascertain reasons why similar results were not found between adolescent sleep onset and tobacco use as those found in adult samples.

Results from the current meta-analysis support experimental data from young adults, aged 18–21 y, which demonstrated that alcohol consumption did not affect sleep onset [79]. Of note, the same study also found that alcohol consumption did lead to more awakenings after sleep initiation [79], indicating that although alcohol may not impede sleep initiation, it may disturb sleep quality.

Neither alcohol nor tobacco use were found to be related to earlier bedtimes. One explanation for such findings is that drinking and/or smoking cigarettes may be more conducive to a party lifestyle [80]. These adolescents may sleep significantly less on weekends than their non-partying peers, hence may be sleep deprived during the week. Consequently, excess sleep pressure may lead to similar weekday bedtimes, despite possible weekend delays.

Despite no evidence for the relationships between alcohol or tobacco and bedtime, and alcohol and TST, small effect sizes were present, with large confidence intervals suggesting the potential for moderating factors. For example, Gutman and colleagues [81] found negative family interactions were associated with increased alcohol consumption and smoking. Given that the present meta-analysis found a link between a negative family environment and sleep variables, it may be that this factor was a confound for the relationship between alcohol and/or tobacco use and sleep, hence a consistent relationship between these substances and sleep could not be found in the present meta-analysis.

Physical activity

Physical activity was beneficial for bedtime, yet it was not associated with sleep latency or total sleep time. Possibly, sports participation only impacts sleep latency in more extreme instances. Of the six studies included in the meta-analysis, only one found an effect of exercise on sleep latency, with athletes falling asleep faster than controls [49]. Looking at individual studies, one interpretation of these findings is that a range may exist, within which the number of hours of exercise does not impact sleep latency, however, in more extreme cases, as in the case of athletes, it helps adolescents fall asleep faster.

A small effect size was present between sleep duration and physical activity, yet no relationship could be determined, due to large CIs. As this suggests the possibility of mediating or moderating factors, this relationship will be discussed in 'Protective Factors'.

Activities outside of school

Participation in activities outside of school hours, such as extracurricular involvement, work, homework and time spent with peers, had no relationship with sleep variables. Once again, there may be a range within which adolescents are able to engage in activities outside of school, wherein their sleep is not greatly affected.

Contrary to the overall meta-analysis results, Dorofaeff and Denny [82] found the hours an adolescent worked in paid employment each week strongly related to less sleep, particularly for students who worked over 3 h per wk. The specific duration of work, or other activities outside of school, was not measured in the present meta-analysis, so the possibility that there is a cut-off, after which sleep is affected more dramatically, could not be assessed.

Moreover, Fuligni and colleagues [65] analysed individuals' sleep length after measuring activity duration over individual days. Less sleep was obtained following days where adolescents had

studied more outside of school. However, sleep duration remained unaffected regardless of whether more or less time had been spent with peers [65]. Furthermore, variability existed for individuals between the amount of time they spent on an activity, per day, and the subsequent night's sleep duration. Daily studying and socializing both had significant individual variance, indicating that adolescents' sleep patterns may not always respond in a systematic manner to daily activities [65]. Consequently, it may be difficult in a therapeutic or educational setting to demonstrate to adolescents how much time can be spent participating in activities outside of school before their sleep is affected. For example, on some nights excessive studying outside of school may lead to less sleep, yet on other nights sleep duration will remain unaffected, regardless of study duration.

Perceived demands from family, school and friends were also related to less sleep, indicating that whether adolescents find these outside of school activities enjoyable or stressful may mediate the effect on sleep duration [65]. For example, lower weekend sleep duration has been found among adolescents who have higher psychological demands at work [83].

In summary, although the present meta-analysis did not find any association between sleep variables and extracurricular involvement, work, homework or time spent with peers, it may be that a “safe” amount of activity involvement exists; that the enjoyment or stress of these activities has an effect on sleep, rather than the activity itself, and; that large individual variability exists in response to the duration of activity participation.

Latitude and longitude

Neither latitude nor longitude were related to any of the sleep variables. The analysis of these variables was limited in that only one or two studies provided results appropriate for analysis. Bedtime was approaching a meaningful negative relationship with longitude, and a positive relationship with latitude.

Borisenkov and colleagues [52] found a 68 min delay in the timing of sleep with a 27° shift westward in longitude. Similarly, a 16 min delay was observed in adolescents who lived as little as 8° further North [52]. As these effects were found between relatively small shifts West and North, further investigation into the effects of longitude and latitude on adolescent sleep is warranted.

Pre-sleep worry

An emerging trend was found for later bedtimes as pre-sleep worries increased, however, overall sleep duration and sleep onset latency remained unrelated. Storfer-Isser and colleagues [34] found that cognitive and emotional arousal before initiating sleep was not related to awakenings after sleep onset, nor was it associated with sleep efficiency (i.e., the percentage of time in bed spent asleep). Thus, despite potential frustration in initiating sleep, if sleep efficiency remains unaltered by cognitive and emotional arousal prior to falling asleep, sleep duration may not be harmed by pre-sleep worry.

Worry just before sleep was not associated with increased sleep latency, due to the large variability in population variance (i.e., the 95%CI crossed zero; Fig. 3), yet it did present a small effect. Specifically, cognitive and/or emotional arousal when going to bed [33,34,38] or while trying to get to sleep [31,61] were included in the meta-analysis. Adolescents with sleep difficulties often catastrophize their anxieties about events during the day and plans for the next day while attempting to initiate sleep [61]. Although cause and effect could not be established in the present meta-analysis, it seems plausible that ruminating on the day's events, worrying about home or school, and thinking about tasks which need to be completed [34] may impede sleep initiation, especially if catastrophic thinking intensifies these thoughts [61]. However, as indicated in the present meta-analysis, it appears that in terms of sleep latency, a large fluctuation surrounds who is affected by worrying thoughts before bedtime.

Furthermore, as adolescents worried more, a trend to go to bed later emerged, although it did not meet Cohen's criteria for a small effect [39]. It may be that adolescents who are more cognitively and emotionally aroused before bed tend to delay bedtime [34,38].

Protective factors

Sleep hygiene

Implementing good sleep hygiene practises was found to be beneficial for bedtimes, sleep latency and sleep duration, having similar effect sizes on all of these sleep dimensions. Sleep hygiene encompasses multiple facets, such as behavioural, physiological and emotional arousal before bed, sleep environment and sleep stability [34]. Hence, in order for an adolescent to have good overall sleep hygiene, many components need to be satisfied. Therefore, if an adolescent has low arousal before bed, has consistent sleep patterns and a good sleep environment, sleep should necessarily benefit, with the more of these components adhered to, the better the sleep. Parents may play a role in the consistency of adolescents' sleeping patterns.

Parent-set bedtime

Parent-set bedtimes were related to longer sleep quantity, but not sleep latency. Moreover, despite relation to earlier bedtimes, to a small extent, there was large variability between populations. This demonstrates that even though some parents send their teenagers to bed earlier than adolescent would choose, this does not necessarily predispose them to lying awake for longer. It appears that adolescents who go to bed at a time elected by their parents fall asleep within the same time frame as their peers who chose their own bedtime, thus may have (and seize) the opportunity to sleep longer before waking up for school. As such, parent-set bedtime may be a protective factor.

Physical activity

Exercise was found to be a protective factor in regards to adolescents' bedtimes, with more exercise linked to an earlier bedtime. Although no relationship was identified between sleep duration and physical activity, large variance across samples suggests the possibility of moderating or mediating factors. Accordingly, the question remains as to when the benefits of exercise on sleep are most likely to arise.

The timing of exercise may impact sleep. In an adult population, performing moderate or vigorous exercise in the morning, as opposed to abstaining from morning exercise, was associated with better sleep quality [84]. Furthermore, those who performed light exercise within 4 h of bed reported sleeping longer than those who did not exercise in this time frame [84]. Although exercising within the hour before bed is not conducive to good sleep hygiene [34], exercising 4 h beforehand, or in the morning, may be beneficial to sleep duration.

Exercise duration and intensity may influence the effects of exercise on sleep [85]. Adolescents from North America who exercised for over 60 min/d, for four or more d/wk, had better odds of obtaining sufficient sleep than adolescents who did not exercise for this duration on any day [85]. Moreover, adolescents who completed a minimum of 20 min of *vigorous* exercise on at least 5 d/wk also had better odds of achieving sufficient sleep than adolescents who did not partake in this exercise [85]. From an opposing point of view, it is possible that adolescents who sleep less feel

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more tired. This lack of energy may present a barrier to exercising [86].

It would be beneficial to conduct experiments to determine which factors, such as exercise timing, intensity and duration, are the most influential on adolescent sleep.

School start times

Given that school start times often determine the wake-up schedules of teenagers, and that delaying school start times can improve adolescents' sleep [11] it is worth considering that a delay in school start times may also be a protective factor. Although adolescents do not have control over the time at which they are required to attend school, school bodies may benefit from considering a delay in start times.

Strengths, limitations and considerations

This is the first meta-analysis to assess a large range of factors which may be associated with adolescent sleep. Insight was provided into what helps adolescents' sleep, rather than merely focussing on what adolescents' should avoid.

Although not included, cultural factors may also impact sleep. Given that culture may change even within the same county we felt it was beyond the scope of this paper to include. Nonetheless, cultural influences should be considered when interpreting and applying these results. For example, in Asian cultures, bedtimes are usually later, and sleep time shorter, than Northern American and European cultures [5].

It is possible that younger and older adolescents' sleep may have offered different relationships with protective and risk factors. For majority of the variables there were not enough studies to divide into a ‘younger’ and ‘older’ age group. Future research, however, may wish to investigate this possibility further.

Technology use is increasing among adolescents [11]. This meta-analysis did not take into account the year of publication, to determine if heavier technology use occurred in more recent publications, and whether this impacted sleep. It is hoped that by only including data from 2003 onwards that this problem was minimised.

Importantly, due to the correlational nature, no cause or effect could be determined, and future experiments will need to ascertain the direction of effect. The present meta-analysis focused on relationships between variables without controlling for other factors, in an attempt to equally summarize variables across studies. There is potential, however, for confounding factors within the relationships explored. For example, age, gender, culture and parent-teenager relationship may all impact the associations between protective and risk factors, and sleep. Furthermore, adolescents who have more structured home environments and parent-set bedtimes may be more likely to have good sleep hygiene, although this could not be determined from this study.

To complicate the understanding of which factors advance or delay bedtime, or prolong or shorten SOL or sleep length, some studies divide the week into weekdays (where parameters are set in place by schools) and weekends (which allow less restricted sleep), while other studies analyse both weekday and weekend data together. Furthermore, the operationalization of both sleep and risk/protective variables frequently vary between studies, making it difficult for the reader to compare results. As an example, caffeine use has been measured by asking adolescents how often they consume coffee, with response options ranging from 0 ‘*never*’ to 4 ‘*often*’ [44], yet in another study, adolescents were asked whether they drank coffee at night to reinvigorate themselves [35]. Yet again, each study in the present meta-analysis which assessed home environment used a different questionnaire, leading to variability between measurement tools. Due to these limitations, understanding the relationships between variables can be confounded, as multiple dimensions must be taken into consideration for proper interpretation.

One solution is to implement standardization of measurement tools when measuring similar constructs. For example the School Sleep Habits Survey is a widely used instrument which assesses various components of adolescent sleep [87]. It measures weekday and weekend sleep variables separately, as well as many protective and risk factors. The survey sleep time measures are correlated with both actigraphy and sleep diary data [87]. Additionally, the Adolescent Sleep Hygiene Scale is also commonly used, assessing many practices before bed [34]. The revised version has an internal validity of $\alpha = .084$ [34]. Where possible, weekday (i.e., Sunday-Thursday night) and weekend (i.e., Friday-Saturday night) sleep variables should be measured separately [87], with clear indication concerning which sleep variables were measured and reported.

Similarly, the reporting of sleep variables and their relationships with variables of interest should be standardized, where appropriate. This would ease comparison of results. For example, correlation coefficients, or means and standard deviations, should be presented either within an article, or in supplementary data files, in order for simple relationships to be determined by readers, and compared to other studies where necessary/appropriate.

Finally, the robustness of meta-analysed findings are dependent on the number of independent studies examining them. In order for the field to gain more insight into protective and risk factors for adolescent sleep, future replication of studies are needed, followed by an updated meta-analysis of new and older data. The present study has included the meta file as a supplementary file should any researchers wish to further analyse, or extend, these findings.

Conclusions

Good sleep hygiene appears to be a protective factor, whereas a negative home environment and evening light appear to be risk factors. Cautious use of technology (other than television), caffeine, tobacco and alcohol should be considered, as these factors are likely to have some negative impact on sleep, as is the case with pre-sleep worry. Further investigation into the effects of parent-set bedtime and physical activity is warranted to determine whether these are protective factors. Experiments are necessary to understand the direction of effect, as well as when and how sleep is most affected by protective and risk factors. Regardless of study design, future research needs standardization of measurement tools and better access to descriptive statistics, through reporting within the article, or supplementary data.

Practice points

1) Good sleep hygiene appears to be a protective factor.
2) Negative home environment and evening light appear to be risk factors.
3) Parent-set bedtime and physical activity are possible protective factors.
4) Technology (other than television), caffeine, tobacco and alcohol need to be used with caution as they may be adversely related to sleep, as may pre-sleep worry.
5) Important to consider the individual/extreme cases, rather than applying a blanket approach (e.g., in therapy).

Research agenda

1) Experiments to determine cause and effect and when effects are strongest.
2) Determine interaction between factors (e.g., multi-tasking with media use).
3) Measure weekday and weekday sleep variables separately.
4) Consistent way of measuring sleep variables and risk and protective factors, as far as applicable.
5) Clear, consistent reporting of results is required. For example, report correlation coefficients or means and standard deviations within the article or as Supplementary Data.

Conflicts of interest

The authors have no conflict of interests concerning this article.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.smrv.2014.08.002.

References

[1] Roberts RE, Roberts CR, Duong HT. Sleepless in adolescence: prospective data on sleep deprivation, health and functioning. J Adolesc 2009;32(5):1045–57.
[2] Carskadon MA, Harvey K, Duke P, Anders TF, Litt IF, Dement WC. Pubertal changes in daytime sleepiness. Sleep 1980;2(4):453–60 [PubMed PMID: 7403744. Epub 1980/01/01].
[3] Warner S, Murray G, Meyer D. Holiday and school-term sleep patterns of Australian adolescents. J Adolesc 2008;31(5):595–608.
[4] Crowley SJ, Acebo C, Carskadon MA. Sleep, circadian rhythms, and delayed phase in adolescence. Sleep Med 2007;8(6):602–12 [PubMed PMID: 17383934. Epub 2007/03/27].
*[5] Gradisar M, Gardner G, Dohnt H. Recent worldwide sleep patterns and problems during adolescence: a review and meta-analysis of age, region, and sleep. Sleep Med 2011;12(2):110–8.
[6] 2011 sleep in America Poll: communication technology in the bedroom. Washington, DC: National Sleep Foundation; 2011.
[7] Gradisar M, Wolfson AR, Harvey AG, Hale L, Rosenberg R, Czeisler CA. The sleep and technology use of Americans: findings from the National sleep Foundation's 2011 sleep in America Poll. J Clin Sleep Med 2013;9(12):1291–9 [PubMed PMID: 24340291. Pubmed Central PMCID: PMC3836340. Epub 2013/12/18].
[8] Gradisar M, Terrill G, Johnston A, Douglas P. Adolescent sleep and working memory performance. Sleep Biol Rhythms 2008;6(3):146–54.
[9] Dewald JF, Meijer AM, Oort FJ, Kerkhof GA, Bogels SM. The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: a meta-analytic review. Sleep Med Rev 2010;14(3):179–89 [PubMed PMID: 20093054. Epub 2010/01/23].
[10] Martiniuk AL, Senserrick T, Lo S, Williamson A, Du W, Grunstein RR, et al. Sleep-deprived young drivers and the risk for crash: the DRIVE prospective cohort study. JAMA Pediatr 2013;167(7):647–55 [PubMed PMID: 23689363. Epub 2013/05/22].
*[11] Borlase BJ, Gander PH, Gibson RH. Effects of school start times and technology use on teenagers' sleep: 1999–2008. Sleep Biological Rhythms 2013;11(1):46–54.
[12] Short MA, Gradisar M, Lack LC, Wright HR, Dewald JF, Wolfson AR, et al. A cross-cultural comparison of sleep duration between US and Australian adolescents: the effect of school start time, parent-set bedtimes, and extracurricular load. Health Educ Behav 2013;40(3):323–30 [PubMed PMID: 22984209. Epub 2012/09/18].
[13] Short MA, Gradisar M, Lack LC, Wright HR, Dohnt H. The sleep patterns and well-being of Australian adolescents. J Adolesc 2013;36(1):103–10.
[14] Carskadon MA. Sleep in adolescents: the perfect storm. Pediatr Clin North Am 2011;58(3):637–47 [PubMed PMID: 21600346. Pubmed Central PMCID: PMC3130594. Epub 2011/05/24].
[15] Carskadon MA, Vieira C, Acebo C. Association between puberty and delayed phase preference. Sleep 1993;16(3):258–62 [PubMed PMID: 8506460. Epub 1993/04/01].
[16] Jenni OG, Achermann P, Carskadon MA. Homeostatic sleep regulation in adolescents. Sleep 2005;28(11):1446–54 [PubMed PMID: 16335485. Epub 2005/12/13].
[17] Taylor DJ, Jenni OG, Acebo C, Carskadon MA. Sleep tendency during extended wakefulness: insights into adolescent sleep regulation and behavior. J Sleep Res 2005;14(3):239–44 [PubMed PMID: 16120098. Epub 2005/08/27].
[18] Teens, technology and lack of sleep: the online Mum. 2011 [cited 2014 12 March 2014]. Available from: http://www.theonlinemom.com/secondary.asp?id=474.
[19] Gaina A, Sekine M, Kanayama H, Sengoku K, Yamagami T, Kagamimori S. Short–long sleep latency and associated factors in Japanese junior high school children. Sleep Biol Rhythms 2005;3(3):162–5.
[20] Weaver E, Gradisar M, Dohnt H, Lovato N, Douglas P. The effect of presleep video-game playing on adolescent sleep. JCSM 2010;6(2):184–9.
[21] Yang YS, Yen JY, Ko CH, Cheng CP, Yen CF. The association between problematic cellular phone use and risky behaviors and low self-esteem among Taiwanese adolescents. BMC Public Health 2010;10:217 [PubMed PMID: 20426807. Pubmed Central PMCID: 2873584].
[22] Van Den Bulck J. Television viewing, computer game playing, and internet use and self-reported time to bed and time out of bed in secondary-school children. Sleep 2004;27(1):101–4.
[23] Pasch KE, Latimer LA, Cance JD, Moe SG, Lytle LA. Longitudinal bi-directional relationships between sleep and youth substance use. J Youth Adolesc 2012;41(9):1184–96 [PubMed PMID: 1222947861; 17134698.].
*[24] Calamaro CJ, Mason TBA, Ratcliffe SJ. Adolescents living the 24/7 lifestyle: effects of caffeine and technology on sleep duration and daytime functioning. Pediatrics 2009;123(6):e1005–10.
[25] Saxvig IW, Pallesen S, Wilhelmsen-Langeland A, Molde H, Bjorvatn B. Prevalence and correlates of delayed sleep phase in high school students. Sleep Med 2012;13(2):193–9 [PubMed PMID: WOS:000301695500013].
[26] Mednick SC, Christakis NA, Fowler JH. The spread of sleep loss influences drug use in adolescent social networks. PloS One 2010;5(3):e9775 [PubMed PMID: 20333306. Pubmed Central PMCID: 2841645].
[27] Condén E, Ekselius L, Åslund C. Type D personality is associated with sleep problems in adolescents. Results from a population-based cohort study of Swedish adolescents. J Psychosom R 2013;74(4):290–5.
[28] Figueiro MG, Rea MS. Evening daylight may cause adolescents to sleep less in spring than in winter. Chronobiol Int 2010;27(6):1242–58 [PubMed PMID: 20653452. Pubmed Central PMCID: PMC3349220. Epub 2010/07/27].
[29] Randler C. Differences in sleep and circadian preference between Eastern and Western German adolescents. Chronobiol Int 2008;25(4):565–75.
[30] Peixoto CAT, da Silva AGT, Carskadon MA, Louzada FM. Adolescents living in homes without electric lighting have earlier sleep times. Behav Sleep Med 2009;7(2):73–80.
*[31] Short MA, Gradisar M, Wright H, Lack LC, Dohnt H, Carskadon MA. Time for bed: parent-set bedtimes associated with improved sleep and daytime functioning in adolescents. Sleep 2011;34(6):797–800.
[32] Randler C, Bilger S, Díaz-Morales JF. Associations among sleep, chronotype, parental monitoring, and pubertal development among German adolescents. J Psychol 2009;143(5):509–20 [PubMed PMID: 213828025; 19943401].
*[33] Billows M, Gradisar M, Dohnt H, Johnston A, McCappin S, Hudson J. Family disorganization, sleep hygiene, and adolescent sleep disturbance. JCCAP 2009;38(5):745–52.
*[34] Storfer-Isser A, Lebourgeois MK, Harsh J, Tompsett CJ, Redline S. Psychometric properties of the adolescent sleep hygiene scale. J Sleep Res 2013;22:707–16 [PubMed PMID: 23682620. Epub 2013/05/21].
[35] Yen C-F, Ko C-H, Yen J-Y, Cheng C-P. The multidimensional correlates associated with short nocturnal sleep duration and subjective insomnia among Taiwanese adolescents. Sleep 2008;31(11).
*[36] Hunter JE, Schmidt FL. Methods of meta-anlaysis: correcting error and bias in research findings. California: Sage Publications Inc; 1990.
[37] Bailey T. Effect size calculator converter (Version 604) [MS Excel workbook]. 2009. Available from: http://psych.cf.ac.uk/home2/mat/.
[38] Tan E, Healey D, Gray A, Galland B. Sleep hygiene intervention for youth aged 10 to 18 years with problematic sleep: a before-after pilot study. BMC Pediatr 2012;12(1):1–9.
[39] Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. New York: Lawrence Erlbaum Associates; 1988.
[40] Brand S, Hatzinger M, Beck J, Holsboer-Trachsler E. Perceived parenting styles, personality traits and sleep patterns in adolescents. J Adolesc 2009;32(5):1189–207.
[41] Teixeira LR, Fischer FM, de Andrade MM, Louzada FM, Nagai R. Sleep patterns of day-working, evening high-schooled adolescents of Sao Paulo, Brazil. Chronobiol Int 2004;21(2):239–52 [PubMed PMID: 15332345. Epub 2004/08/31].

* The most important references are denoted by an asterisk.

[42] Loessl B, Valerius G, Kopasz M, Hornyak M, Riemann D, Voderholzer U. Are adolescents chronically sleep-deprived? An investigation of sleep habits of adolescents in the Southwest of Germany. Child Care, Health Dev 2008;34(5):549–56 [PubMed PMID: 18549435. Epub 2008/06/14].
[43] Gradisar M, Dohnt H, Trenowden S, Gardner G, Paine S, Starkey K, et al. A randomized controlled trial of cognitive-behavior therapy plus bright light therapy for adolescent delayed sleep phase disorder. Sleep 2011;34(12): 1671–80.
[44] Chung K-F, Cheung M-M. Sleep-wake patterns and sleep disturbance among Hong Kong Chinese adolescents. Sleep 2008;31(2):185.
[45] Huang R, Ho SY, Lo WS, Lai HK, Lam TH. Alcohol consumption and sleep problems in Hong Kong adolescents. Sleep Med 2013;14(9):877–82.
[46] Megdal SP, Schernhammer ES. Correlates for poor sleepers in a Los Angeles high school. Sleep Med 2007;9(1):60–3.
[47] Collado Mateo MJ, Diaz-Morales JF, Escribano Barreno C, Delgado Prieto P, Randler C. Morningness-eveningness and sleep habits among adolescents: age and gender differences. Psicothema 2012;24(3):410–5 [Epub 2012/07/04].
[48] Tzischinsky O, Shochat T. Eveningness, sleep patterns, daytime functioning, and quality of life in Israeli adolescents. Chronobiol Int 2011;28(4):338–43 [PubMed PMID: 21539425. Epub 2011/05/05].
[49] Brand S, Gerber M, Beck J, Hatzinger M, Pühse U, Holsboer-Trachsler E. High exercise levels are related to favorable sleep patterns and psychological functioning in adolescents: a comparison of athletes and controls. J Adolesc Health 2010;46(2):133–41.
[50] Honda M, Genba M, Kawakami J, Nishizono-Maher A. A sleep and life-style survey of Japanese high school boys: factors associated with frequent exposure to bright nocturnal light. Sleep Biological Rhythms 2008;6(2): 110–9.
[51] Ortega F, Chillón P, Ruiz J, Delgado M, Albers U, Álvarez-Granda J, et al. Sleep patterns in Spanish adolescents: associations with TV watching and leisure-time physical activity. Eur J Appl Physiol 2010;110(3):563–73.
*[52] Borisenkov MF, Perminova EV, Kosova AL. Chronotype, sleep length, and school achievement of 11- to 23-year-old students in northern European Russia. Chronobiol Int 2010;27(6):1259–70 [PubMed PMID: 20653453. Epub 2010/07/27].
[53] Garmy P, Nyberg P, Jakobsson U. Sleep and television and computer habits of Swedish school-age children. JOSN 2012;28(6):469–76 [PubMed PMID: 22472633].
*[54] Pieters D, De Valck E, Vandekerckhove M, Pirrera S, Wuyts J, Exadaktylos V, et al. Effects of pre-sleep media use on sleep/wake patterns and daytime functioning among adolescents: the moderating role of parental control. Behav Sleep Med 2012. in press. null-null.
[55] King D, Delfabbro P, Zwaans T, Kaptsis D. Sleep interference effects of pathological electronic media use during adolescence. Int J Ment Health Addict 2014;12(1):21–35.
[56] Shochat T, Flint-Bretler O, Tzischinsky O. Sleep patterns, electronic media exposure and daytime sleep-related behaviours among Israeli adolescents. Acta Paediatr (Oslo, Nor : 1992) 2010;99(9):1396–400 [PubMed PMID: 20377536. Epub 2010/04/10].
[57] Drescher AA, Goodwin JL, Silva GE, Quan SF. Caffeine and screen time in adolescence: associations with short sleep and obesity. JCSM 2011;7(4): 337–42 [PubMed PMID: 21897768. Pubmed Central PMCID: 3161764].
[58] Bryant Ludden A, Wolfson AR. Understanding adolescent caffeine use: connecting use patterns with expectancies, reasons, and sleep. Health Educ Behav 2010;37(3):330–42.
[59] Heath M, Sutherland C, Bartel K, Gradisar M, Williamson P, Lovato N, et al. Does one hour of bright or short-wavelength filtered tablet screenlight have a meaningful effect on adolescents' pre-bedtime alertness, sleep, and daytime functioning? Chronobiol Int 2014;31(4):496–505 [PubMed PMID: 24397302. Epub 2014/01/09].
[60] Arora T, Hussain S, Hubert Lam KB, Lily Yao G, Neil Thomas G, Taheri S. Exploring the complex pathways among specific types of technology, self-reported sleep duration and body mass index in UK adolescents. Int J Obes 2013;37(9):1254–60.
[61] Hiller RM, Lovato N, Gradisar M, Oliver M, Slater A. Trying to fall asleep while catastrophising: what sleep-disordered adolescents think and feel. Sleep Med 2014;15(1):96–103.
[62] Dworak M, Schierl T, Bruns T, Struder HK. Impact of singular excessive computer game and television exposure on sleep patterns and memory performance of school-aged children. Pediatrics 2007;120(5):978–85 [PubMed PMID: 17974734].
[63] King DL, Gradisar M, Drummond A, Lovato N, Wessel J, Micic G, et al. The impact of prolonged violent video-gaming on adolescent sleep: an experimental study. J Sleep Res 2013;22(2):137–43 [PubMed PMID: 23137332. Epub 2012/11/10].
[64] Kalak N, Gerber M, Kirov R, Mikoteit T, Pühse U, Holsboer-Trachsler E, et al. The relation of objective sleep patterns, depressive symptoms, and sleep disturbances in adolescent children and their parents: a sleep-EEG study with 47 families. J Psychiat Res 2012;46(10):1374–82.
[65] Fuligni AJ, Hardway C. Daily variation in adolescents' sleep, activities, and psychological well-being. JRA 2006;16(3):353–78.
[66] Oshima N, Nishida A, Shimodera S, Tochigi M, Ando S, Yamasaki S, et al. The suicidal feelings, self-injury, and Mobile phone use after lights out in adolescents. J Pediatr Psychol 2012;37(9):1023–30.
[67] Engelhardt CR, Mazurek MO, Sohl K. Media use and sleep among boys with autism spectrum disorder, ADHD, or typical development. Pediatrics 2013;132(6):1081–9 [PubMed PMID: 24249825].
[68] Tynjälä J, Kannas L, Levälahti E, Välimaa R. Perceived sleep quality and its precursors in adolescents. Health Promot Int 1999;14(2):155–66.
[69] Minors DS, Waterhouse JM, Wirz-Justice A. A human phase-response curve to light. Neurosci Lett 1991;133(1):36–40.
[70] Cajochen C, Frey S, Anders D, Spati J, Bues M, Pross A, et al. Evening exposure to a light-emitting diodes (LED)-backlit computer screen affects circadian physiology and cognitive performance. J Appl Physiol (Bethesda, Md 1985) 2011;110(5):1432–8 [PubMed PMID: 21415172. Epub 2011/03/19].
[71] Higuchi S, Motohashi Y, Liu Y, Maeda A. Effects of playing a computer game using a bright display on presleep physiological variables, sleep latency, slow wave sleep and REM sleep. J Sleep Res 2005;14(3):267–73.
[72] McLean T. Tech hits teen sleeping patterns Sydney, Australia: the Australian. 2007 [updated 12 March 2014]. Available from: http://www.theaustralian.com.au/australian-it-old/tech-hits-teen-sleeping-patterns/story-e6frgamo-1111114311958.
*[73] Cain N, Gradisar M. Electronic media use and sleep in school-aged children and adolescents: a review. Sleep Med 2010;11(8):735–42.
[74] Van den Bulck J. Adolescent use of mobile phones for calling and for sending text messages after lights out: results from a prospective cohort study with a one-year follow-up. Sleep 2007;30(9):1220–3.
[75] Madden M, Lenhart A, Duggan M, Cortesi S, Gasser U. Teens and technology 2013. Washington, D.C: Harvard University; 2013.
[76] Tavernier R, Willoughby T. Sleep problems: predictor or outcome of media use among emerging adults at university? J Sleep Res 2014;23(4):389–96.
[77] Phillips BA, Danner FJ. Cigarette smoking and sleep disturbance. Arch Intern Med 1995;155(7):734–7 [PubMed PMID: 7695462. Epub 1995/04/10].
[78] Jaehne A, Unbehaun T, Feige B, Lutz UC, Batra A, Riemann D. How smoking affects sleep: a polysomnographical analysis. Sleep Med 2012;13(10): 1286–92.
[79] Chan JKM, Trinder J, Andrewes HE, Colrain IM, Nicholas CL. The acute effects of alcohol on sleep architecture in late adolescence. ACER 2013;37(10): 1720–8.
[80] Kuntsche E, Gmel G. Alcohol consumption in late adolescence and early adulthood—where is the problem? SMW 2013;143:w13826 [PubMed PMID: 23888405].
[81] Gutman LM, Eccles JS, Peck S, Malanchuk O. The influence of family relations on trajectories of cigarette and alcohol use from early to late adolescence. J Adolesc 2011;34(1):119–28.
[82] Dorofaeff TF, Denny S. Sleep and adolescence. Do New Zealand teenagers get enough? J Paediatr Child Health 2006;42(9):515–20.
[83] Fischer FM, Oliveira DC, Nagai R, Teixeira LR, Lombardi Júnior M, MdRDO Latorre, et al. Job control, job demands, social support at work and health among adolescent workers. Rev Saude Publica 2005;39:245–53.
[84] Buman M, Phillips B, Youngstedt SD, Kline CE, Hirshkowitz M. Does nighttime exercise really disturb sleep? results from the 2013 National sleep foundation sleep in America Poll. Sleep Med 2014;15(7):755–61.
[85] Foti KE, Eaton DK, Lowry R, McKnight-Ely LR. Sufficient sleep, physical activity, and sedentary behaviors. Am J Prev Med 2011;41(6):596–602.
[86] O'Dea JA. Why do kids eat healthful food? Perceived benefits of and barriers to healthful eating and physical activity among children and adolescents. J Am Diet Assoc 2003;103(4):497–501.
[87] Wolfson AR, Spaulding NL, Dandrow C, Baroni EM. Middle school start times: the importance of a good Night's sleep for young adolescents. Behav Sleep Med 2007;5(3):194–209.

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